

Valiguna flava (Heynemann, 1885) from Indonesia and Malaysia:
Redescription and Comparison with *Valiguna siamensis* (Martens, 1867)
(Gastropoda: Soleolifera: Veronicellidae)

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Abstract. We redescribe and figure *Valiguna flava*, an almost unknown Southeast-Asian land slug. Detailed morphology, radula, jaw and living specimens of *Valiguna flava* were studied for the first time, based on material recently collected in Borneo and on the holotype. *Vl. flava* is also compared with *Valiguna siamensis*, the only other species of the genus, which is for the first time recorded in China.

Key Words: Morphology, anatomy, land slug, Borneo, Australasian region.

INTRODUCTION

Veronicellidae Gray, 1840 includes a large number of species of land slugs totally without shell (Thomé et al., 2006). Currently, 27 generic taxa are recognized for the family, which are distributed widely in the humid tropics and subtropics (Hoffmann, 1925; Forcart, 1953; Thomé, 1975; Gomes & Thomé, 2004). For the Oriental and Australian regions, Gomes & Thomé (2004) recognized six different genera (total of 13 species): *Filicaulis* Simroth, 1913, *Laevicaulis* Simroth, 1913, *Sarasinula* Grimpe & Hoffmann, 1924, *Semperula* Grimpe & Hoffmann, 1924, *Valiguna* Grimpe & Hoffmann, 1925 and *Veronicella* Blainville, 1817.

Originally, the taxon *Valiguna* was proposed by Grimpe & Hoffmann (1925a) as a subgenus of *Semperula* to include *Vaginula schneideri* Simroth, 1895 from Eastern Sumatra (Indrapura, Tandjong Kuba). However, in the same year that Grimpe & Hoffmann (1925a) proposed the taxon *Valiguna*, they rejected it and considered *Vaginula schneideri* a subspecies of *Semperula siamensis* (Martens, 1867) (Hoffmann, 1925; Grimpe & Hoffmann, 1925b). Only later, when Hoffmann (1941) found specimens which

he considered a new species very close to *Vaginula schneideri* (*Vl. isseli* Hoffmann, 1941), he reconsidered *Valiguna*, this time as a genus. Hoffmann (1941) included in *Valiguna*, *Vl. schneideri* and *Vl. isseli*, species in which the vas deferens does not open terminally (*acrocaulis* form, such as species of *Sarasinula*) nor basally in the penis (*pleurocaulis* form, such as species of *Semperula*), having an intermediate form, the *acropleurocaulis* or *pseudopleurocaulis* form.

Recently, Gomes & Thomé (2004) examined the holotype of *Vaginula flava* Heynemann, 1885 (considered by Hoffmann, 1925 a synonym of *Semperula maculata*) and also the original and subsequent descriptions of *Vl. schneideri* and *Vl. isseli* (Simroth, 1895; Grimpe & Hoffmann, 1925a, b; Hoffmann, 1925, 1941). They concluded that these three species are synonyms and that *Valiguna flava* is the valid name since it has priority. Gomes & Thomé (2004) also proposed the inclusion of *Semperula siamensis* into the genus *Valiguna* because this species also has an *acropleurocaulis* penis. According to Gomes & Thomé (2004), *Vl. flava* has records from Nias, Borneo and Indrapura (Indonesia), and *Valiguna siamensis* from Galle (Sri Lanka) and Petshaburi (Thailand). Both

species were insufficiently described in the original description. *Vaginulus reticulatus* Westerlund, 1883, which is a synonym of *Vl. siamensis* according to Gomes & Thomé (2004), was redescribed by Thomé (1984), although *Vl. flava* has not been studied since then.

Our primary purpose is, for the first time, to describe and figure in detail the morphology, radula, jaw, and living specimens of *Valiguna flava*. The study is based on samples recently collected from Borneo and on the holotype. The species is also compared with *Valiguna siamensis*, the only other species of the genus, based on material from China and on the paratypes of *Vaginulus reticulatus* (synonym of *Vl. siamensis*).

MATERIAL AND METHODS

Six living and adult specimens of *Vl. flava*, which were collected in Borneo and deposited in the Museum BORNEENSIS of Universiti Malaysia Sabah, were analyzed. The holotype and paratype of this species, deposited in the Natural History Museum (BMNH-1880.10.6), London, England were also studied.

Vl. flava was also compared with four specimens of *Vl. siamensis* deposited in the Museum of the Institute of Zoology, Chinese Academy of Sciences, Beijing (China) (lots ZMIZ01091, ZMIZ01092), from Yunnan and Guangxi, China. The type-material of *Vaginulus reticulatus* Westerlund, 1883 (13 specimens) (synonym of *Vl. siamensis* according to Gomes & Thomé, 2004), deposited at Swedish Museum of Natural History (Stockholm, Sweden) was also examined (lots SMNH 6427, SMNH 3753).

The specimens of both species were dissected under a stereomicroscope for studying the internal structures. Drawings were done using a camera lucida. Two jaws and two radulae (from each species) were extracted under the stereomicroscope and later analyzed using a scanning electron microscope (SEM Philips XL 30).

The terminology used and the morphological and anatomical characteristics described and illustrated are those usually considered diagnostic in the Veronicellidae (Hoffmann, 1925; Coifmann, 1935; Forcart, 1953; Barker, 2001; Thomé et al., 2002; Gomes & Thomé, 2001, 2004).

Valiguna flava (Heynemann, 1885)

(Figures 1–12)

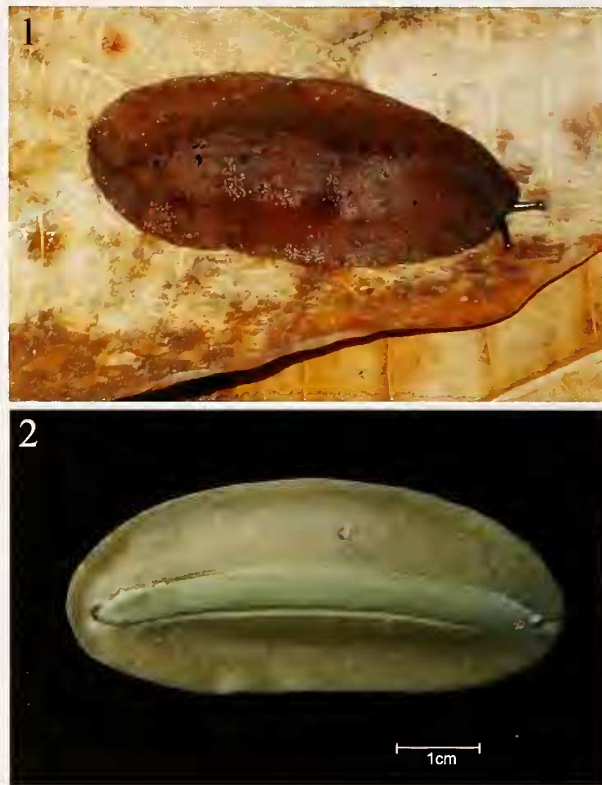
Vaginula flava Heynemann, 1885:10–11.

Vaginula schneideri Simroth, 1895:7–8.

Semperula (Valiguna) schneideri; Grimpe & Hoffmann 1925a: 391–392.

Semperula siamensis schneideri; Hoffmann, 1925: 181–182; Grimpe & Hoffmann, 1925b:18–19, 31–33.

Valiguna schneideri; Hoffmann, 1941:236.



Figures 1–2. External characteristics of *Valiguna flava*. 1, dorsal position of a living specimen (BOR/MOL 3411); 2, ventral position of a fixed specimen (BOR/MOL 3439).

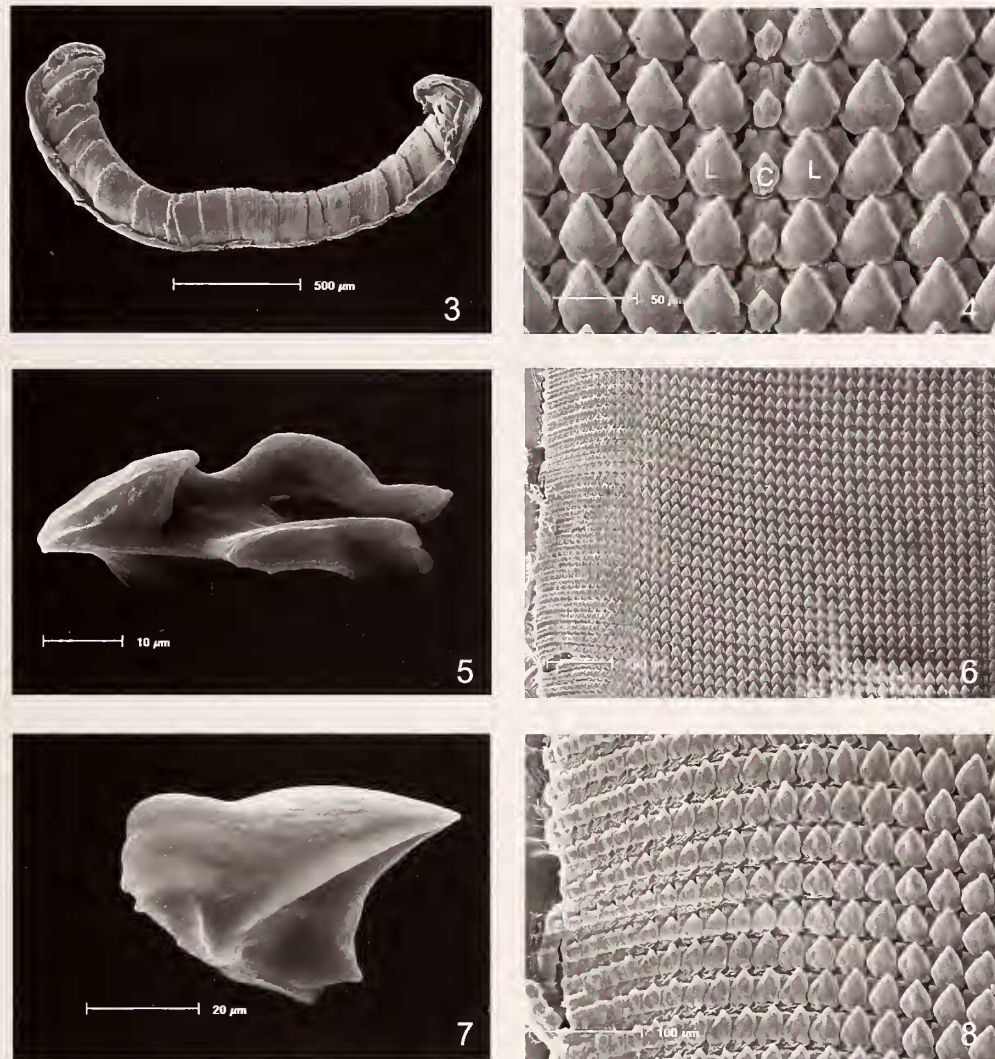
Valiguna isseli Hoffmann, 1941:234.

Diagnostic Features

The main diagnostic structure in Veronicellidae is the penis. The penis of *Valiguna flava* has a glans and a base completely distinct from each other. The base is a cylindrical structure, without peculiarities in outer surface. The glans starts from a flap that surrounds the distal extremity of the penis base. First, it is cylindrical, but then it curves, forming a peak, in whose extremity the vas deferens opens. In the dorsum of the curvature (penis apex) is a cylindrical structure covered by dentate and serrated formations (Figures 9–12).

External Characteristics

The specimens are relatively large and they have an oval body (Figures 1–2). The notum (dorsal region) is smooth only with some widely spaced granules. There are some scattered blackish spots and also a narrow light line on the dorsum (Figure 1). This last one is in the middle of the notum and is not always clearly visible. The notum ground coloration ranges from pale



Figures 3–8. Radula and jaw of *Valiguna flava* (BOR/MOL 3409). 3, entire jaw; 4, lateral (L), central (C) and lateral (L) teeth, respectively; 5, lateral view of a central tooth; 6, medium part of the right half of the radula; 7, lateral view of a lateral tooth; 8, lateral teeth in the edges of the radula.

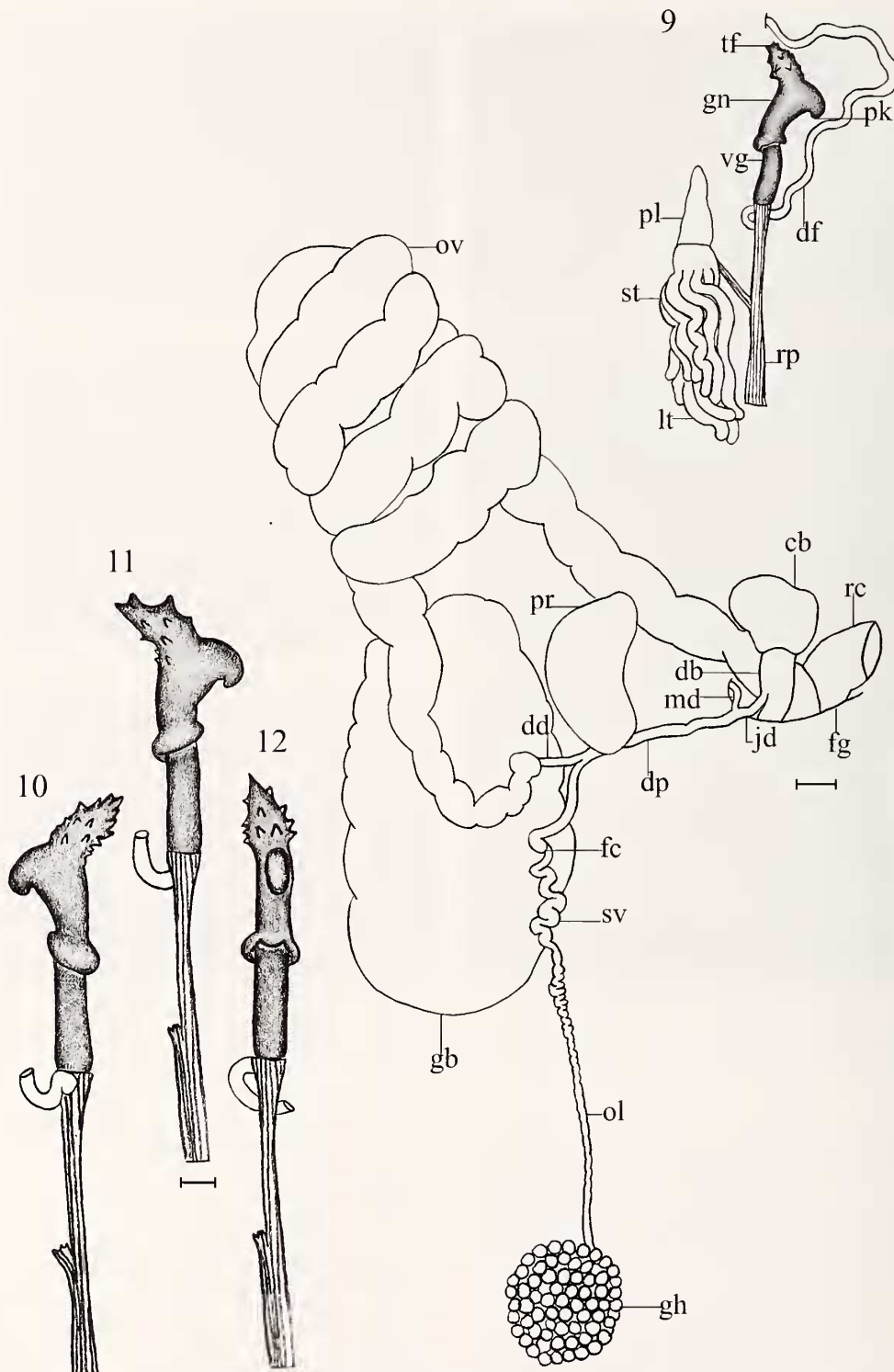
yellowish brown to dark reddish brown. The hyponotum is also pigmented from pale yellowish brown to dark reddish brown, depending of the notum coloration. However, it is always much lighter than the notum and has a homogeneous coloration, without spots or lines or only with few tiny blackish spots (Figure 2). The sole is light beige and very narrow, having less than half of the hyponotum width. The female pore is situated at ca. 45% of the length of the body measured from the front, and it is far from the pedal groove by ca. $\frac{2}{5}$ the width of the hyponotum. In all specimens the female pore is surrounded by a slender line of black pigmentation (Figure 2).

Holotype measurements (mm): body length (70.00), body width (29.00), sole width (5.44) and hyponotum width (8.11). Measurements (mm) (6 other specimens):

body length (45–60), body width (22–30), sole width (2.5–4.8) and hyponotum width (5.2–10.5).

Digestive System

The mouth is followed by a buccal bulb (= pharynx), where the radula and the jaw lie. There are two salivary glands with very slender, ramified and delicate acini connected to the buccal bulb. The buccal bulb is connected to the esophagus, which is followed by the gastric crop. The latter is barely delimited from the esophagus, both having almost the same diameter. The gastric crop leads into a stomach, which is long (twice longer than wide). Two lobules of the digestive gland open into the stomach, one anterior and another one posterior. The anterior lobe does not totally cover the



Figures 9-12. Reproductive system in *Valiguna flava* (BOR/MOL 3409). 9, complete reproductive system; 10-12, three different positions of the penis (cb, bursa copulatrix; db, duct of the bursa copulatrix; dd, distal posterior deferens; df, vas deferens; dp, proximal posterior deferens; fc, fertilization complex; fg, female genital pore; gb, albumen gland; gh, hermaphroditic gland; gn, glans; jd, canalis junctor; lt, long tubules; md, middle deferens; ol, spermioduct; ov, oviduct; pk, peak, in whose extremity the deferens opens; pl, penial gland papilla; pr, prostate; rc, rectum; rp, penis retractor muscle; st, short tubules; sv, seminal vesicle; tf, structure covered by dentate and serrated formations; vg, penis base. Scale bar: 1 mm.

anterior intestinal loop. The intestine starts from the stomach, follows to the anterior region where it forms a loop (the anterior intestinal loop) and then continues back to the posterior region. Near the height of the female pore, the intestine penetrates in the body wall, where the rectum begins. The rectum continues to the end of the body where it opens via the anus. The latter is located centrally in the body and is totally hidden over the sole. The anal opening is represented by a fissure. Neither a circular opening (with a defined border) nor an opercular membrane is found. The anal opening floor is formed by well developed folds that sometimes seem papillae. The nephridium does not have an external aperture. It is probably connected to the rectum within the body wall.

The jaws are well arquated and narrow. They are formed by an average of 24 wide and superposed ribs. The three ribs of the middle are somewhat higher and less distinct from the others (Figure 3).

The radula has 93–95 teeth per transverse row, which is formed by one symmetrical central or rhachis tooth (Figures 4–5), flanked on both sides by 46–47 lateral teeth (Figures 6–7). The dental formula is $C/1+L46-47/2$. The lateral teeth are smaller towards the edges of the radula (Figure 8).

Pedal and Pallial Nerves, Pedal Aortic System

One pair of pallial and one of pedal nerves run from the central nervous system towards the posterior extremity of the body cavity (Barker, 2001). They are parallel and together from the central nervous system until near the height of the bursa copulatrix. After, they are parallel but separated from each other and run like that until the end of the body cavity. The pedal aortic artery begins at the level of the central nervous system and runs between the nerves (centrally) until around the level of the bursa copulatrix.

Pedal Gland

The pedal gland, located on the anterior extremity of the sole under the head, is short and straight. It is broad in its proximal portion (in the aperture), narrowing in the middle and with the posterior extremity rounded and somewhat broadened (producing a goblet-shape). It has two different areas: one external lighter and one internal yellowish. The posterior extremity of the gland receives a wide pedal gland artery (Coifmann, 1935).

Reproductive System

The bursa copulatrix (= spermatheca or gametolitic gland) is almost circular, but somewhat concave in the middle. It has a cylindrical duct a little longer than the

bursa copulatrix. The canalis junctor (Barker, 2001; Gomes & Thomé, 2004) penetrates in the duct of the bursa copulatrix, near to the half of the total length of the duct. The oviduct is wider near to the female genital pore, involving the duct of the bursa copulatrix (Figure 9).

The penis has a glans and a base well differentiated. The base of the penis is somewhat cylindrical and smooth. The glans starts from an surrounding structure (as a flap) at the distal extremity of the penis base; it is initially cylindrical and smooth, but quickly tapers and curves forming a peak, in whose extremity the vas deferens opens. In the dorsum of the curvature is a cylindrical structure covered by dentate and serrated formations, which is in the distal extremity of the penis (Figures 9–12).

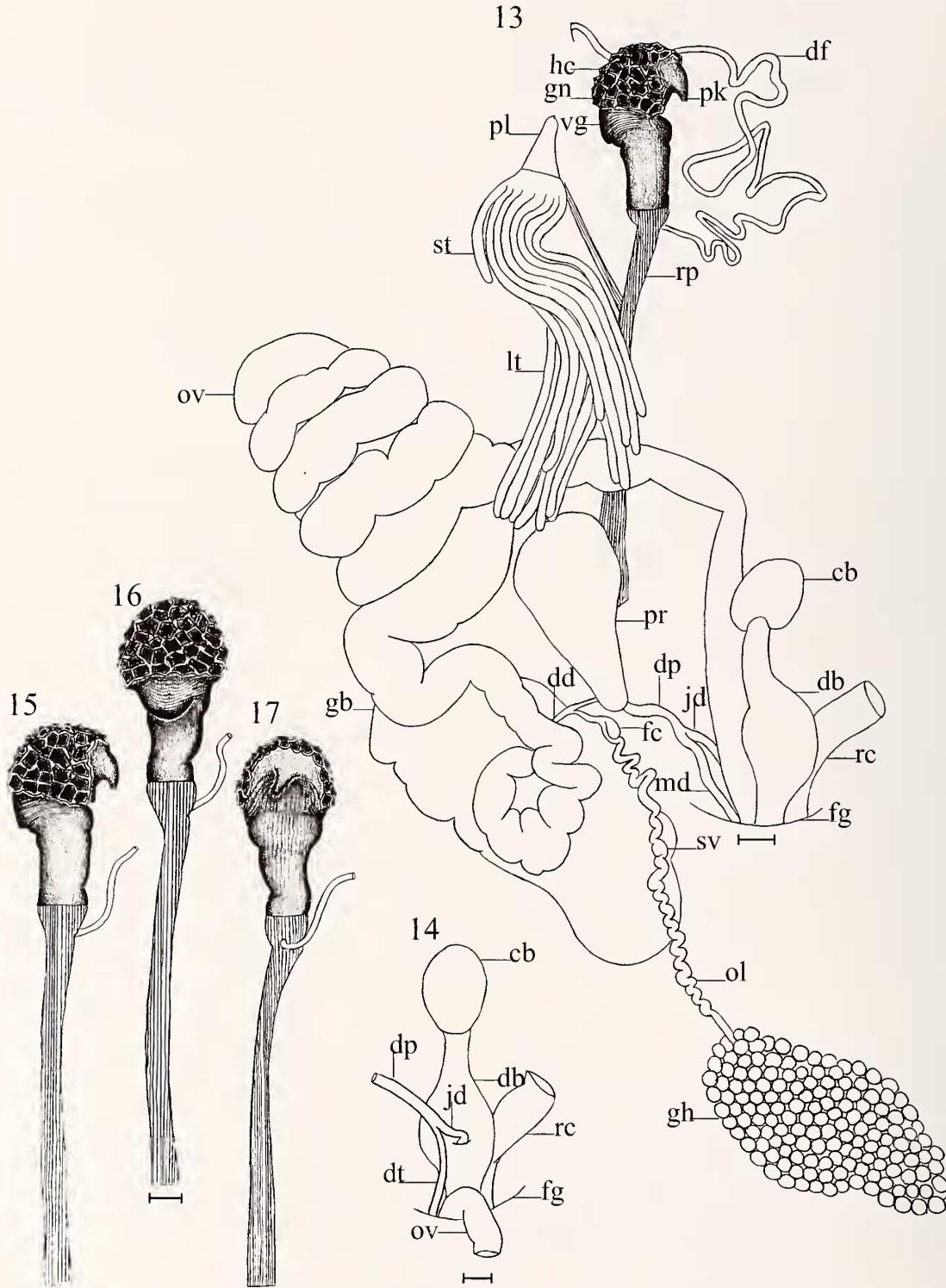
The penial gland is small and has a length similar to the length of the penis. It is formed by a papilla and by about 15 short tubules (they exceed a little the height of the pericardium). The papilla is relatively long, with around half of the tubules' length. The tubules are not differentiated in groups according to length, although subtle differences in tubule lengths is observed.

Distribution: Islands of Sumatra and Borneo (Fig. 18).

Natural history: They were found on the forest floor, at night and early in the morning, in one case more or less clustered around a rotten log.

Type-material: Holotype. INDONESIA, Borneo: P. E. Gerrard col. (BMNH 1880.10.6.4). Other materials. MALAYSIA, Sabah: Danum Valley Field Centre, ca. 60 km W of Lahad Datu, primary dipterocarp forest, ca. 300 m asl. (04°58'00"N 117°48'00"E), 2 specimens, 2003.80.W, P. Craze & M. Schilthuizen col. (BOR/MOL 3409); Danum Valley Borneo Rainforest Lodge, 1 specimen, 2000.84.W, C. Rutjes col. (BOR/MOL 3410); Kota Kinabalu Distr., Poring Hot Springs, 660 m asl. (06°02'87"N 116°42'16"E), 1 specimen, 2001.59.W, M. Schilthuizen & P. Koomen col. (BOR/MOL 3411); Interior Prov., Tenom (behind Perkasa Hotel), 327–400 m asl. (05°07'17"N 115°56'40"E), 1 specimen, 2003.89.W, M. Schilthuizen col. (BOR/MOL 3438); Kinabalu National Park (Poring Hot Springs), 500 m asl., 1 specimen, 2003/03/24 (2003.26.W), M. Schilthuizen col. (BOR/MOL 3439).

The lot deposited at Natural History Museum in London (England) (BMNH 1884.1.10.1), which is identified as a paratype of *Vl. flava*, is not *Vl. flava*. In this specimen (adult), that has not been dissected yet, the penis (the main diagnostic characteristic) is completely different. It is probably an unknown species of Veronicellidae.



Figures 13–17. Reproductive system in *Valiguna siamensis* (ZMIZ01092). 13, complete reproductive system; 14, detail of the bursa copulatrix; 15–17, three different positions of the penis (cb, bursa copulatrix; db, duct of the bursa copulatrix; dd, distal posterior deferens; df, vas deferens; dp, proximal posterior deferens; fc, fertilization complex; fg, female genital pore; gb, albumen gland; gh, hermaphroditic gland; gn, glans; hc, honeycomb aspect structure; jd, canalis junctor; lt, long tubules; md, middle deferens; ol, spermioduct; ov, oviduct; pk, peak, in whose extremity the deferens opens; pl, penial gland papilla; pr, prostate; rc, rectum; rp, penis retractor muscle; st, short tubules; sv, seminal vesicle; vg, penis base). Scale bar: 1 mm.

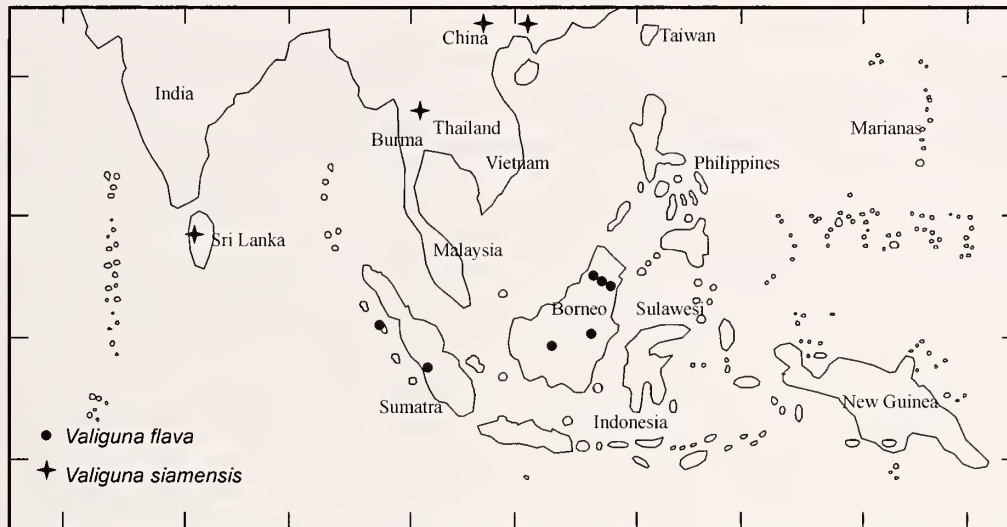


Figure 18. Map showing the distribution of *Valiguna flava* and *Valiguna siamensis*, considering bibliography records and the lots recently collected in the north of Borneo and China.

DISCUSSION

Vl. flava and *Vl. siamensis* are clearly close species. They share several morphological characteristics, although important differences are also found between them.

The penis is the structure that most notably discriminates *Vl. flava* from *Vl. siamensis* and even from the other species of the family. The dentate and serrated formation found in the distal extremity of the penis of *Vl. flava* is very characteristic and it is found only in this species of Veronicellidae. In *Vl. siamensis*, the vas deferens also opens in a lateral peak and a well developed base is found. But, in this species the penis has a formation like a “honeycomb” located in the distal extremity (Figures 13–17). It is a complex structure, which is practically absent in juvenile specimens. The bursa copulatrix region has also some differences. In *Vl. siamensis*, the bursa copulatrix duct is extended in the medium region, assuming a domed aspect. In *Vl. siamensis* the bursa duct is fairly longer than the copulatrix bursa, different from *Vl. flava*. In this species, the bursa is small and assumes a form from spherical to elliptical. In both species, the canalis junctor penetrates in the bursa copulatrix duct, not in the bursa itself (as in many other species of Veronicellidae).

The other internal characteristics are very similar between *Vl. flava* and *Vl. siamensis*. The characteristics of the digestive system as well as radula and jaw do not show significant differences between both species. Also the disposition of the pairs of pedal and pallial nerves and pedal aortic system are the same in *Vl. flava* and *Vl. siamensis*. The pedal gland is also similar. Moreover, all the other described characteristics regarding

on the reproductive system (as copulatrix bursa region and penial gland) are very similar between both species.

The body form differs between *Vl. flava* and *Vl. siamensis*. The first one has an oval body while the other is longer and narrower, although in both species the sole width is smaller than half the width of the right hyponotum. Unfortunately, the coloration can not be compared since the specimens of *Vl. siamensis* from China were all completely discolored. The specimens of *Vs. reticulatus* examined by Thomé (1984), and again by us, were also discolored. Externally, *Vl. flava* can be identified mainly by presence of wide blackish spots in the notum, although there is some variation in the intensity of the notum ground coloration (Figure 1).

Vl. siamensis, previously redescribed by Thomé (1984) when he studied *Va. reticulatus* from Galle (synonyms), is recorded for the first time to China (Yunnan and Guangxi) (Figure 18).

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